

CALIFORNIA ENERGY COMMISSION

PUBLIC INTEREST ENERGY RESEARCH

2003 ANNUAL REPORT



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Cover images



- a. Skylights in a commercial building with a suspended ceiling. PIER-funded research developed *Design Guidelines for Skylights with Suspended Ceilings*. The project includes a construction design protocol that allows architects, engineers, ceiling suppliers, and skylight manufacturers to design and install cost-effective skylighting systems.
- b. Cylindrical surface burner in a 200-hp boiler used to demonstrate a new method of burner operation for ultra-low NO_{X} burners. The new method reduces power consumption for an ultra-low NO_{X} burner by 25 percent.
- c. 100 kW flywheel power system undergoing laboratory testing at Livermore, California, facility.
- d. Kern Mallow—one of the federally listed endangered species being studied by an Exploratory Grant project.
- e. Low Emissions Atmospheric Metering Separator (LEAMS) technology reduces the emissions from geothermal drilling and well operations.

CALIFORNIA ENERGY COMMISSION

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Project Manager

Terry Surles, PIER Program Director

Marwan Masri, Deputy Director Technology Systems Division

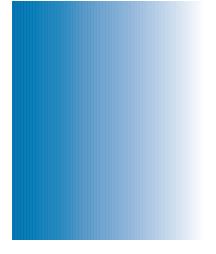
ABSTRACT

Each year, Californians consume \$30 to 35 billion worth of electricity, and \$12 to 15 billion worth of natural gas, well over \$100 million on a hot summer day. Yet California continues to face significant challenges in meeting its electricity needs in a way that improves and maintains system reliability, promotes economic growth, and protects the environment and public health. To help address these issues, the Legislature established the Public Interest Energy Research (PIER) program at the California Energy Commission, funding the program with payments from ratepayers. PIER is working to develop information and technologies that address critical public interest needs and can help avoid the next energy crisis. Based on a review of the program from 1998 to 2002, ratepayer benefits are projected to be between \$2 and \$5 for every dollar contributed. This report presents an overview of the program, analyzes its benefits, highlights its accomplishments for 2003, and identifies its plans for 2004.

PREFACE

In 1996, the Legislature established the Public Interest Energy Research (PIER) program at the California Energy Commission, funding the program with payments from all ratepayers. The PIER program conducts public interest energy research that seeks to improve the quality of life for California citizens by developing environmentally sound, safe, reliable, and affordable electricity services and products. Public interest energy research includes the full range of RD&D activities that advance science and technology not adequately provided by competitive and regulated markets.

The 2003 PIER Annual Report presents an overview of the program, analyzes its benefits, highlights its accomplishments for 2003, and identifies its plans for 2004. The appendices provide summaries of each of the more than 500 projects funded by the program.



CONTENTS

CHAPTER 1

The California Energy Perspective and the PIER Program Why Are Research and Development Critical to California? | 1 What Can PIER Do to Help Prevent the Next Energy Crisis? | 2 Concluding Thoughts | 10

CHAPTER 2

Overview of the PIER Program

Background | 11 Vision | 12 Mission | 12 Implementing State Policy | 13 Technology Transfer | 13

CHAPTER 3

Accomplishments for 2003

Residential and Commercial Buildings End-Use Energy
Efficiency | 15
Industrial/Agricultural/Water End-Use Energy Efficiency | 16
Renewable Energy Technologies | 18
Environmentally-Preferred Advanced Generation | 19
Energy-Related Environmental Research | 20
Energy Systems Integration | 21
Energy Innovations Small Grant | 23

CHAPTER 4

Program Successes = Benefits for California

Benefits from PIER Commercial Successes | 25 Emerging Products and Technologies: Update on 2002 Success Stories | 25 PIER Products Placed into Commercial Use in 2003 | 27

2003 PIER ANNUAL REPORT

CHAPTER 5

Plans for 2004

Residential and Commercial Buildings End-Use Energy Efficiency | 34

Industrial/Agricultural/Water End-Use Energy Efficiency \mid 35

Renewable Energy Technologies | 36

Environmentally-Preferred Advanced Generation | 37

Energy-Related Environmental Research | 38

Energy Systems Integration | 40

Energy Innovations Small Grant | 41

ATTACHMENT 1

Acknowledgments | 42

ATTACHMENT 2

Independent Review Panel | 44

Endnotes | 46

APPENDICES

Project Summaries

Appendix 1

Residential and Commercial Buildings End-Use Energy Efficiency

Multiyear Projects Started in 2003

Active Projects from Previous Years

Projects Completed in 2003

Projects Completed in 2002

Projects Completed in 2001

Projects Completed in 2000

Projects Completed in 1999

Appendix 2

Industrial/Agricultural/Water End-Use Energy Efficiency

Multiyear Projects Started in 2003

Active Projects from Previous Years

Projects Completed in 2003

Projects Completed in 2002

Projects Completed in 2001

Projects Completed in 2000

Projects Completed in 1999

Appendix 3

Renewable Energy Technologies

Multiyear Projects Started in 2003 Active Projects from Previous Years

Projects Completed in 2003

Projects Completed in 2002

Projects Completed in 2001

Projects Completed in 2000

Projects Completed in 1999

Appendix 4

Environmentally-Preferred Advanced Generation

Multiyear Projects Started in 2003

Active Projects from Previous Years

Projects Completed in 2003

Projects Completed in 2002

Projects Completed in 2001

Projects Completed in 2000

Projects Completed in 1999

Appendix 5

Energy-Related Environmental Research

Multiyear Projects Started in 2003

Active Projects from Previous Years

Projects Completed in 2003

Projects Completed in 2002

Projects Completed in 2001

Projects Completed in 2000

Projects Completed in 1999

Appendix 6

Energy Systems Integration

Multiyear Projects Started in 2003

Active Projects from Previous Years

Projects Completed in 2003

Projects Completed in 2002

Projects Completed in 2001

Projects Completed in 2000

Appendix 7

Energy Innovations Small Grant

Multiyear Projects Started in 2003

Active Projects from Previous Years

Projects Completed in 2003

Projects Completed in 2002

Projects Completed in 2001

2003 PIER ANNUAL REPORT iV



the California ENERGY PERSPECTIVE and the PIER PROGRAM

WHY ARE RESEARCH AND DEVELOPMENT CRITICAL TO CALIFORNIA?

As the fifth largest economy in the world, Californians consume \$30 to 35 billion worth of electricity and \$12 to 15 billion worth of natural gas each year, well over \$100 million on a hot summer day. Yet California continues to face significant challenges in meeting its electricity needs in a way that improves and maintains system reliability, promotes economic growth, and protects the environment and public health. Developing and implementing the policies, strategies, and technologies needed to accomplish these goals requires a robust and creative research program.

To accomplish these goals, the Legislature established the Public Interest Energy Research (PIER) program at the California Energy Commission, funding the program with payments from ratepayers (Endnote 1). Based on a review of the program from 1998 to 2002, ratepayer benefits are projected to be between \$2 and \$5 for every dollar contributed. This conservative analysis does not account for intrinsic public interest benefits related to improvements in the environment, electric system reliability, and increased jobs and economic activity (Endnote 2).

The Energy Commission's PIER program is working to develop information and technologies that address critical public interest needs and can help avoid the next energy crisis. The program brings together parties with differing aims, creates better pathways to market for emerging technologies, and informs public decision makers as they debate energy issues. Through its efforts, the PIER program helps resolve issues and facilitates the development and

PIER addresses four key policies:

- 1. Enhancing energy efficiency, demandside management, and demand response programs
- 2. Diversifying...
- 3. Strengthening...
- 4. Continuing...

deployment of technologies with broad public benefit, focusing on public interest concerns not addressed in the private or academic sectors.

Additionally, California's energy policies emphasize energy efficiency, demand response, and renewable energy in contrast with the federal government's focus on coal and nuclear research. Consequently, California can rely neither on the federal government nor on private interests to meet its energy policy objectives. California needs to continue an effective public interest energy research and development program if it is to meet its broad policy goals of affordable, reliable, and environmentally sensitive electricity supplies, as well as the state's need to protect public health and safety.

WHAT CAN PIER DO TO HELP PREVENT THE NEXT ENERGY CRISIS?

In the 2003 Integrated Energy Policy Report (IEPR), the Energy Commission concluded that "California's energy system appears stabilized for now, but faces critical challenges in the years ahead," and that targeted research and development is a "necessary means of introducing new, more efficient, and cleaner technologies into the market" (Endnote 3). To this end, the PIER program addresses California energy policies in four key areas:

- 1. Enhancing energy efficiency, demand-side management, and demand response programs
- 2. Diversifying electricity supplies by investing in renewable and other clean energy technologies
- 3. Strengthening California's energy infrastructure to provide for reliability
- 4. Continuing California's environmental stewardship.

ENHANCING ENERGY EFFICIENCY, DEMAND-SIDE MANAGEMENT, AND DEMAND RESPONSE PROGRAMS

Current Trends in Electricity Supply and Demand

Based on current trends, as early as 2006, the demand for electricity is projected to outstrip supply, especially during periods of peak demand. Between 2004 and 2013, natural gasfired generation is expected to increase from 36 to 43 percent, reflecting California's increasing dependence on natural gas to generate electricity. Figure 1 shows the capacity of new additions by fuel type in the Western Electricity Coordinating Council (WECC) area since 2000. Of the more than 57,000 megawatts (MW) of capacity that came on-line during this time, 89 percent is fueled with natural gas (Endnote 4).

As the demand for natural gas has increased, so have prices. Since the 1990s, natural gas prices have doubled and become more volatile. If price volatility continues, businesses and

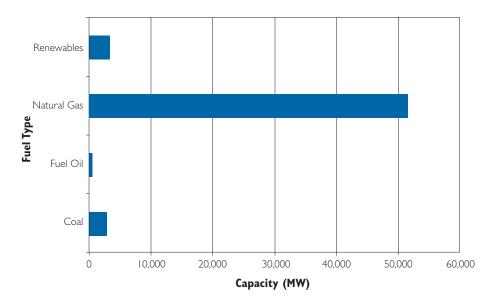


Figure 1 Power Plant Additions in the Western Electricity Coordinating Council Since 2000

Source: California Energy Commission, 2004.

consumers alike will pay higher prices for electricity and other goods and services with high energy content.

Merely planning for and permitting new power plants will not be the only solution for two reasons. First, because natural gas is the fuel of choice for almost all new facilities, building more gas-fired power plants will only lead to more dependence on natural gas, and with that, more natural gas price hikes and volatility.

Second, although a spike in permitting new generation capacity occurred during the energy crisis, and many new units have come on-line, the rate of new additions has declined significantly since 2002. The construction of a number of these permitted facilities has been delayed or, in some cases, cancelled because of concerns in the financial markets and regulatory uncertainty.

Thus, California will need to fill the growing gap by reducing demand with new, efficient enduse technologies, demand-side management, and demand response technologies, as well as increasing supplies with new renewable energy systems. The state needs a more diverse mix of energy resources if we are to avoid becoming overly dependent on natural gas. PIER is developing a portfolio of affordable energy supplies that will deliver cost-effective technology solutions to meet California's long-term energy needs.

Reducing California's Overall Demand for Electricity California has been very successful over the last 25 years in developing new efficiency

technologies and commercializing them in the marketplace. Figure 2 shows how, after the oil embargo in the mid-1970s, California implemented aggressive conservation programs that resulted in holding per capita electricity consumption flat after 1974. In contrast, per capita electricity consumption in the United States continued to climb 2 percent a year and has now risen 50 percent. With California's electricity bill now about \$32 billion a year, the avoided 50 percent represents an annual savings of \$16 billion. In terms of 50 percent avoided fuel usage and the associated pollution, this is equivalent to having taken 18 million cars off California roads forever.

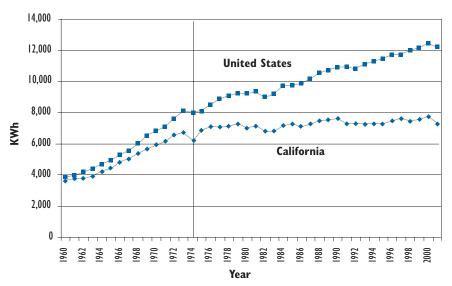


Figure 2 Electricity Consumption Patterns in the United States and California

Source: California Energy Commission, 2004.

However, the 2003 Energy Action Plan requires that we go even further:

California should decrease its per capita electricity use through increased energy conservation and efficiency measures. This would minimize the need for new generation, reduce emissions of toxic and criteria pollutants and greenhouse gases, avoid environmental concerns, improve energy reliability and contribute to price stability (Endnote 5).

To achieve this goal, research, development, and demonstration (RD&D) must continue to provide California with a supply of new technologies to incorporate into appliance and building standards, demand-side management and demand response programs, and retail ENERGY STAR® products.

Two programs that helped California maintain level per capita electricity use since 1974 are Titles 20 and 24, the appliance and building energy-efficiency standards, respectively

(Endnote 6). PIER research can help provide critical information and develop innovative energy-efficient technologies to support regular updates to these standards.

To help reduce demand, PIER focuses on electricity use in residential and commercial buildings, which accounts for approximately two-thirds of the state's electricity use. Air conditioning is close to 30 percent and lighting is close to 10 percent of the state's electrical demand on a hot summer day. Efficiency improvements in these areas are particularly critical in reducing peak demand and high consumer utility bills. If new dynamic pricing for peak demand periods is introduced, efficiency improvements will be even more essential in reducing consumer costs. These high price signals are also likely to stimulate innovations in efficiency.

PIER has a longstanding relationship with the U.S. Department of Energy (DOE) Buildings Efficiency program for collaboratively funding activities. Some of our greatest successes are in air conditioning and lighting technology. For example, the program funded an air conditioning unit with two-stage, indirect-direct evaporative cooling, which is more reliable, less costly, and more efficient than earlier prototypes. An analysis of test data shows the new unit has an annual energy savings of 89 to 95 percent over conventional cooling systems and a peak load reduction of 80 to 89 percent for typical California use. This new technology is in the process of being licensed for commercialization.

In another project, PIER has focused on improving lighting in California schools, which currently spend nearly \$450 million a year on electricity. The PIER program has funded new technologies to develop an integrated school lighting system to improve energy efficiency and reduce energy bills significantly, allowing schools to spend more on books and supplies.

As a result, policy makers will have effective solutions to address future energy supply inadequacies and reduce demand during a "heat storm"—an extended period of hot temperatures—while contributing to lower consumer costs.

Demand Response Programs to Reduce Peak Demand

In addition to energy-efficient technologies, advanced technologies are needed to monitor and adjust energy usage during periods of peak demand. These programs are referred to as demand response (DR) programs.

The PIER program is working closely with the California Public Utility Commission (CPUC) to develop new strategies and rules for DR programs that will reduce peak electricity demand. Demand response systems and technologies now being brought to market to help realize this goal will be important additions for California policy makers, grid operators, and end users. Several PIER programs focus on developing new technologies and information systems that allow end users to respond automatically to high demand/price signals.

PIER is collaborating with the new DOE Office of Electric Transmission and Distribution on a number of activities in technology areas that include communication and control

technologies for supporting DR programs. For example, PIER has funded the development of communications and control software to improve a plant operator's ability to curtail load in response to critical price or emergency signals. This software is designed to meet both the plant operator's and the utility's need to shed demand and maintain system integrity.

DIVERSIFYING ELECTRICITY SUPPLIES BY INVESTING IN RENEWABLE AND OTHER CLEAN ENERGY TECHNOLOGIES

Using energy more efficiently and reducing demand are critical to meeting broad state energy and environmental goals. However, the state will also need to augment its supplies with renewable resources to provide for more balanced use of energy resources, as well as protecting the environment by reducing emissions from fossil fuel generation.

PIER addresses four key policies:

- 1. Enhancing...
- 2. Diversifying electricity supplies by investing in renewable and other clean energy technologies
- 3. Strengthening...
- 4. Continuing...

The 2003 IEPR recommended that the state accelerate its 20 percent Renewables Portfolio Standard (RPS) goal from 2017 to 2010 (Endnote 7). California now uses 12 percent renewable electricity. To meet this goal, though, with non-hydro renewable energy resources such as solar, wind, and geothermal, the renewable portfolio must grow at 1 percent a year.

More recently, Senator Byron Sher introduced legislation, Senate Bill (SB) 1478, to establish the state's intent to reach an RPS goal of 33 percent by 2020 (Endnote 8). PIER is playing an important role in making that ambitious goal achievable, providing critical information to other state agencies and developing more cost-effective and efficient renewable energy technologies and applications.

To bring these renewable supplies on-line, the utilities will solicit bids from renewable generators interested in selling renewable electricity to meet their RPS obligations. To prepare for these solicitations, the CPUC must adopt a "least-cost, best-fit" process for investor-owned utilities (IOUs) to evaluate which bids are best suited to meet their RPS procurement obligations. The IOUs must rank the bids they receive in a process that accounts for the "...ongoing utility expenses resulting from integrating and operating eligible renewable energy resources." (Endnote 9)

In response, the PIER program assembled a team of independent experts to develop a methodology for assessing the costs associated with integrating more renewable resources into California's electricity system. This analysis provides cost information that the utilities will use as they compare bids from renewable generators competing in the first procurement to meet the RPS. PIER completed Phase 1 of the *California Renewables Portfolio Standard Renewable Generation Integration Cost Analysis* in late 2003, and expects to continue to refine and finalize

the analysis in subsequent phases of the study (Endnote 10). By providing this timely assistance, the Energy Commission has played a critical role in helping California move forward in diversifying the state's energy supplies.

PIER has also embarked on a much needed evaluation of state renewable energy resources, analyzing the relationship between the geographical location of the supply and the centers of demand, along with the transmission system requirements to link the two. This project will describe how renewable resources located within the state can be used to address projected electricity issues of the future, the best locations for developing and deploying renewables, and the resulting economic and environmental benefits. Once implemented, this system will allow California to better plan to meet its RPS goals.

In one technology development effort, the Energy Commission funded the SunRoof™ system, a competitive solution to bring flat roof photovoltaic (PV) systems to the commercial market. This system has streamlined features that increase electricity production and make it quicker and faster to install than competing systems. Furthermore, the system is made with materials that are highly resistant to wind or earthquake damage, has a 25-year design life, and meets or exceeds all industry standards.

PIER addresses four key policies:

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 provide for reliability
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STRENGTHENING CALIFORNIA'S ENERGY INFRASTRUCTURE TO PROVIDE FOR RELIABILITY

Even if the state had adequate supplies to meet future demand and could minimize natural gas price volatility, some areas of the state would still have problems in receiving sufficient electricity because of transmission system bottlenecks.

The current transmission system that links supply to areas of demand is strained. When supplies cannot be quickly moved to meet demand, catastrophic outages can occur. During California's electricity crisis in 2000 and 2001, transmission constraints were one of the main contributing factors. Although the state has taken steps to reduce or remove constraints, these

efforts have not been sufficient to resolve the bottlenecks fully. For example, PIER is working closely with the California Independent System Operator (CA ISO) and the utilities to develop the tools for grid operators to manage and operate the transmission system more effectively.

The program is developing a portfolio of tools in three critical areas: transmission system efficiency, distributed energy resources to improve reliability, and end-use power quality and reliability for 21st century technologies.

• Transmission System Efficiency

Transmission bottlenecks prevent critical supplies from reaching entire geographic areas in California such as the San Francisco peninsula. Although solving these problems will ultimately be a long-term effort, PIER is funding some short-term solutions as well.

Currently, PIER is funding a real-time monitoring system that allows grid operators to calculate, monitor, and move electricity safely through California's existing transmission lines, without adding expensive additions or upgrades. This monitoring system performed well when tested on a segment of Southern California Edison's transmission system and is now available on the market.

PIER is co-funding and collaborating with the DOE Office of Electric Transmission and Distribution to develop a long-term, Office of Management and Budget-approved collaboration in technology areas that will help develop additional real-time transmission system management tools.

One such project, the Consortium for Energy Reliability and Transmission Solutions (CERTS) program, developed a voltage management tool for energy reliability and transmission solutions. Had this system been in use last year in Ohio, the August 2003 blackout might have been minimized or even prevented. With this tool, grid operators can monitor the system with real-time data and identify potential problems. The tool has been installed at both the Folsom and Alhambra CA ISO control centers.

Distributed Energy Resources to Improve Reliability

California businesses and other ratepayers want the reliability, economy, and flexibility of generating their own power. While advances in so-called distributed generation (DG) technology render it feasible to install these resources at specific locations, distributed generation presents potential technical problems to utilities, in terms of safety, when they are connected to the grid.

Because distributed generation provides significant consumer benefits, the number of these projects interconnecting to the grid has risen about 29 percent a year since the energy crisis, equating to over 370 MW of capacity (Endnote 11). This trend is expected to continue, with new studies indicating that more than 12,000 North American energy users are considering distributed generation to meet their electricity needs (Endnote 12). These projects range from 10 kilowatts (kW) to 10 MW per system installed.

PIER has stepped in to help solve the potential problems these distributed energy systems create for utility planners and operators. Working with all interested parties, including the CPUC, the Energy Commission developed and published the *California Interconnection Guidebook* for developers and utility customers to streamline the process of bringing these resources on-line (Endnote 13). The guidebook describes the requirements and processes associated with interconnecting distributed energy resources in accordance with Rule 21

(Endnote 14), which will help ensure that safety, reliability, and power quality requirements are properly addressed.

• End-Use Power Quality and Reliability for 21st Century Technologies

Electricity needs in the 21st century will differ substantially from the past. New computer and digital technologies will require much improved power quality. Reliability is also critical for new high-technology manufacturing systems. PIER is funding a number of projects to help improve reliability by reducing transmission congestion and improving power quality.

PIER funded a demonstration of a harmonic filter to reduce power quality problems for computer equipment with "switching" power supplies. A test, conducted in a Sacramento facility belonging to the California Franchise Tax Board, demonstrated that the filter could substantially eliminate the problems, reducing the likelihood of damage to digital systems in the building and providing the additional benefit of reducing energy use by 4 to 6 percent.

CONTINUING CALIFORNIA'S ENVIRONMENTAL STEWARDSHIP

Although technology development does not always drive these needs, public health, economic well-being, and environmental quality issues do require improved scientific underpinnings to better inform the public debate. PIER is helping to develop the information needed to provide an energy infrastructure that minimizes negative health effects and protects air quality, water quality, and ecological systems.

While energy drives our economy, its use is also our largest source of pollution, impacting all environmental media—land, air, and water. PIER is conducting a number of studies to determine the specific impacts to California and how they can be mitigated. We also examine the potential impacts of new energy technologies and look for approaches that can be incorporated during development to ameliorate them. As part of our efforts, PIER works closely with the California

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Air Resources Board (ARB), California Department of Water Resources (DWR), and California Department of Forestry (CDF) to ensure that our activities are relevant to and supportive of state environmental policies and initiatives.

In conjunction with California manufacturers and DOE, PIER has developed and accelerated the introduction of clean energy system technologies that reduce pollutant emissions. Part of this effort involves working closely with ARB. All of the fossil fuel technology solicitations have been developed with ARB staff support to ensure that any successful technologies would *surpass* future air quality standards. For example, PIER funding was used to develop the first commercial demonstration of a new low-emission combustion technology. The project is a retrofit

of a gas turbine with a catalytic combustor, which significantly reduces oxides of nitrogen emissions without exhaust cleanup or toxic chemicals. The system, operating in a combined heat and power (CHP) application, now provides electricity and steam to the 120-building state Sonoma Developmental Center in Eldridge, California, and exceeds the 2007 ARB emissions standards.

Once the Sonoma demonstration is complete and the first commercial sale of the technology occurs, the PIER contract stipulates that royalty payments are to be paid back into the program. The first royalty payment is expected in 2004.

Regarding climate change, the California DWR participated with PIER in an effort to evaluate the impacts of changes in precipitation patterns, forest growth, habitats for California wildlife, energy use, coastal flooding, and human health as a result of global climate change. Largely as a result of the PIER-sponsored study, the DWR explicitly recognized the importance of climate change as an issue in future water resource planning in its 2003 five-year plan. PIER is currently developing alternative scenarios that DWR intends to use extensively in preparing its 2008 five-year plan.

PIER is the lead for the DOE-funded multistate Western Regional Partnership for Carbon Sequestration, which includes Washington, Oregon, Nevada, and Arizona. PIER also collaborates with the National Oceanic and Atmospheric Administration on regional climate change research and assessment.

CONCLUDING THOUGHTS

For many reasons, California's energy mix and policies will always differ from the nation's, which is why the state must have its own energy RD&D program. PIER focuses on California's unique environmental, economic, and demographic challenges, allowing state policy makers to craft state-specific solutions to our energy needs. Without a state-funded program, California would have to rely on energy technologies and solutions developed at the federal level and without specific consideration of the state's unique resources; range of business needs; diverse geography, climatic regions, and ecosystems; and societal needs.

California must continue its public interest energy RD&D activities if it is to meet its broad policy goals of affordable, reliable, and environmentally safe electricity supplies as well as protect public health and safety. With its own robust program, the state can retain the ability to influence federal policies and spending patterns on energy RD&D. When RD&D is coordinated with and guided by state energy goals, the policies become incentives for acquiring financing and implementing new strategies and technology, which in turn drives new regulatory policies and market incentives that will keep California's future bright.



OVERVIEW of the PIER PROGRAM

BACKGROUND

In 1996, California adopted far-reaching legislation that deregulated much of the state's electric services industry (1996 Statutes, Chapter 854, hereinafter referred to as Assembly Bill (AB) 1890). Article 7 of AB 1890 was enacted to ensure that the benefits obtained from important public purpose programs, such as public interest energy RD&D, would not be lost in the newly deregulated environment. As a result, starting on January 1, 1998, and extending through 2001, Public Utilities Code (PUC) Section 381 required that California's electric investor-owned utilities collect at least \$62.5 million to fund energy-related public interest RD&D activities "not adequately addressed by competitive and regulated markets." In September 2000, SB 1194 (Sher) and AB 995 (Wright) were passed, extending the PIER program surcharge for an additional 11 years, from January 2001 to January 2012.

In AB 1890, the Energy Commission was authorized to receive and administer these funds, as designated by the CPUC, to conduct public interest RD&D, subject to administration and expenditure criteria. In 1997, the CPUC determined that at least \$61.8 million should be transferred annually from the major IOUs to the Energy Commission for specified public interest energy research (D.97-02-014). These funds are subject to the administrative and expenditure criteria adopted by the Legislature in 1997 through SB 90, which are contained in Public Resources Code (PRC) Section 25620 et seq.

In September 2002, SB 1038 (Sher, Chapter 515, Statutes of 2002), was signed into law. This bill restated the goal of the PIER program and requires that the Energy Commission use a portfolio approach to achieve that goal:

The goal of the program is to provide public value for the benefit of California and its citizens through the development of technologies which will improve environmental quality, enhance system reliability, increase efficiency of energy-using technologies, lower system costs, or provide other tangible benefits.

SB 1038 further requires the Energy Commission to establish and convene an advisory board on a regular basis to make recommendations guiding the selection of PIER programs and projects to be funded. This board is to be composed of representatives from the Energy Commission, consumer and environmental organizations, and electrical corporations. The bill also requires the Energy Commission to report on the actual costs and results of projects compared to their expected costs and benefits.

On March 1, 2001, the Energy Commission provided the Governor and Legislature with the Five-Year Investment Plan, 2002 Through 2006, for the PIER program as required by SB 90. In September 2002, the Governor signed SB 1038 into law, authorizing the Energy Commission to use the adopted Five-Year Investment Plan, 2002 Through 2006, to ensure compliance with the policies and provisions of PUC Section 399.7 in administering the public RD&D programs.

In 2002, PIER conducted external technical reviews of each program area. The recommendations of these committees were used in planning individual program area activities for 2003 and 2004.

With the enactment of SB 1038, an Independent Review Panel (IRP) was reconstituted. This second IRP must report its findings and recommendations regarding the status of the program to the Legislature and Governor in 2005. Several members of the previous panel are on the new panel, which was charged with two major areas of responsibility. First, since the first IRP made a series of recommendations in its March 2001 report to the Energy Commission, the new IRP was asked to review and evaluate the implementation status of those recommendations. Second, the new IRP was asked to evaluate trends of improvement or lack of improvement for the overall PIER program. In accordance with SB 1038, the interim report will be completed in March 2004.

VISION

PIER's vision for California is to provide a clean, affordable, reliable, and resilient supply of electricity where "smart," efficient customers have energy choices that can meet their individual needs, and California's industries can grow and prosper. The PIER program will support and catalyze science and technology advancements by providing leveraged funding to establish California as the world leader in energy efficiency and clean, advanced energy technologies and systems.

MISSION

As its mission, the PIER program conducts public interest energy research that seeks to improve the quality of life for California citizens by developing environmentally sound, safe, reliable, and affordable electricity services and products. Public interest energy research includes the full range of RD&D activities that advance science and technology not adequately provided by competitive and regulated markets.

IMPLEMENTING STATE POLICY

The PIER program implements AB 1890, SB 90, AB 995, SB 1194, and SB 1038; the Energy Commission's RD&D strategic plan; and the Five-Year Investment Plan, 2002 Through 2006. These documents identify the essential state policies and objectives for energy-related public interest research. In turn, the results from the PIER program will provide input for developing future state energy policies.

The Five-Year Investment Plan, 2002 Through 2006, identifies elements of California's energy-related circumstances and trends, including deregulation, demographics, technological advances, economic conditions, social values, political factors, climate, and environmental factors. In particular, the plan highlights the following concerns:

- Rapid growth in demand, particularly peak demand, as a threat to reliability and power quality
- Need for balance between meeting energy needs and protecting the environment
- Market uncertainty and price volatility as they impact energy delivery and use.

The overarching objective of strengthening California's economy is supported by all PIER program activities. The program relies on six objectives that serve as discriminators for better selection of program activities:

- Improving energy cost/value
- Improving the environment, public health, and safety
- Improving electricity reliability, quality, and sufficiency
- Addressing important RD&D gaps
- Providing greater choices for California consumers
- Connecting to near-term market applications.

In addition, PIER objectives and activities are closely linked to California's energy policies, as outlined in the *Energy Action Plan* and the *IEPR*.

TECHNOLOGY TRANSFER

The value of energy RD&D is lost if the results are not made available to potential users, investors, or marketers. Many smaller businesses do not have the resources or expertise to launch their own clean energy technology or products. The PIER program addresses these technology transfer issues through a variety of innovative means.

In October 2003, the PIER program expanded its business incubator program with the Environmental Business Cluster, one of the nation's leading business incubators and an affiliate of the National Alliance of Clean Energy Business Incubators. In 2003, the Environmental Business Cluster completed its pilot program to provide business consulting services to ten selected clean energy companies with PIER-funded projects. The pilot program proved very successful. Four companies successfully commercialized their technologies. Key results include negotiating a licensing strategy and licensing agreement, taking several products to market,

announcing a Technology 100 Award, developing project and business plans, providing fundraising assistance, and assisting with the development and implementation of both marketing and manufacturing plans.

The Energy Commission and the Environmental Business Cluster developed a plan for an expanded program to assist 20 more companies. Business services available to clean energy entrepreneurs from Cluster staff and consultants include business plan development; marketing plans and market research; business and revenue model development; human resource and staffing advice; sales advice; and assistance with building management teams and advisory boards, fund-raising and funding presentations, customer presentations, competitive analysis, operations management, and manufacturing design. This year the Cluster has also developed a technology commercialization program for selected PIER companies in association with San Jose State University.

In November 2003 the Energy Commission, along with the National Renewable Energy Laboratory (NREL) and the National Alliance of Clean Energy Business Incubators, cosponsored the 16th Industry Growth Forum. This forum focused on bringing together clean energy companies and potential investors, and it offered some PIER-funded projects the chance to present their business plans to venture capitalists and angel investors. Three PIER companies assisted by the Cluster were selected to attend, and the Cluster helped them prepare for and attend the forum.

In technology transfer efforts in 2003, the program produced 5 more success stories in an ongoing series, bringing the number of completed success stories to 14. Those success stories are highlighted on the dynamic PIER website, which contains all published final reports on research contracts, a program-area information focus, and information about funding opportunities. More success stories are under development and will be completed in 2004.

In addition, PIER cosponsored technical conferences with other distinguished organizations to leverage PIER funds for the more efficient transfer of information and technical knowledge.

ACCOMPLISHMENTS for 2003

RESIDENTIAL AND COMMERCIAL BUILDING END-USE ENERGY EFFICIENCY

In 2003, the PIER buildings program portfolio grew to nearly \$50 million, with approximately \$40 million in active research projects. A number of exciting projects have been completed, and the program continues to actively work with California utilities and others to maximize market connections for this public interest research. Work completed this year includes the following:

- A low-cost, energy-efficient kitchen downlighting system for residential applications was developed. This system uses less than half the energy of comparable systems currently available while providing higher-quality light output. The system is currently being manufactured by a major lighting manufacturer and demonstrated by several builders in the state.
- An improved indirect evaporative heat exchanger was developed.
 This heat exchanger resolves many of the prior barriers to evaporative cooling equipment and will provide consumers with a comfortable, cost-effective, energy-efficient alternative to standard air conditioning.
- Public-domain building specifications were developed to enable architects to specify energy- and resource-efficient building designs more easily.
- Secondary loop supermarket refrigeration systems were investigated to validate energy savings and environmental benefits via reduced use of refrigerants.

2003 PIER ANNUAL REPORT 15

- Duct testing was conducted that culminated in an approved American Society for Testing and Materials (ASTM) standard that will be referenced by T-24 building energy standards.
- Studies were conducted to validate energy and productivity savings associated with daylighting, which will lead to more energy-efficient lighting in buildings.
- Design guidelines for large and small heating, ventilating, and air conditioning (HVAC) systems were developed that can significantly reduce commercial HVAC energy use and peak demand.
- A functional test guide for air handlers was developed to facilitate commissioning (performance testing and verification) of large air conditioning systems.
- An integrated ceiling design guideline was developed that will stimulate the use of skylights in commercial buildings with T-bar ceilings and lead to more energy-efficient lighting in buildings.
- Automated diagnostics for commercial air conditioning equipment were developed. These
 diagnostics are similar to the ones found in modern cars. They provide timely identification
 and diagnosis of malfunctions that cause energy waste and unnecessarily high utility bills.

INDUSTRIAL/AGRICULTURAL/WATER (IAW) END-USE ENERGY EFFICIENCY

In 2003, the IAW program continued funding and managing RD&D projects in the high-tech and food processing sectors. It commenced new efforts for developing RD&D plans for water and wastewater treatment utilities and electricity users in the irrigation sectors. The plans were developed in collaboration with the industrial end users. The following specific actions and projects were undertaken in the IAW sectors in 2003.

INDUSTRY

- In June 2003, through a competitive solicitation, the IAW program awarded \$2.1 million to seven RD&D projects that met the food processing industry needs. These projects are expected to reduce peak demand by 190 MW, electricity consumption by 406 gigawatt-hours (GWh), and natural gas consumption by 22.2 million therms.
- High-tech industries such as electronics, e-commerce services (data centers, server farms), and biotechnology companies suggested undertaking RD&D projects that would provide an ability to mitigate the possibility of brownouts and problems associated with reliability and power quality. Industry concerns and suggestions were included in the RD&D road map.
- IAW invested in projects to facilitate real-time pricing (RTP) and DR capabilities for industrial customers. The RTP and DR programs will allow industries to manage their electrical load and costs in an orderly manner in response to requests from the utility to shed loads.

- A system was developed that could send the RTP or DR signal to the industrial customer and allow a utility to verify the receipt of the signal and verify commencement of required action by the end-use customer. The newly developed system was installed and successfully validated at two industrial sites.
- A project was initiated for benchmarking the efficiency of compressed air utility systems. It
 successfully developed an energy efficiency measurement index, called the Compressed Air
 System Energy Efficiency Index (EEI), and tested it at various industrial users. One utility
 plans to use it in 2004 as part of its major energy efficiency rebate program, called Standard
 Performance Contracts.

AGRICULTURE

California's agriculture relies heavily on water transport, storage, and groundwater pumping. Air emission regulations have made it necessary to curtail the use of diesel pumps and may require switching to electric pumps. California's agriculture also depends heavily on electricity for irrigation and post harvest processing. Low electricity costs and power reliability have become critical for a successful and sustainable agricultural operation.

• PIER began an initiative to work with California's irrigation community to better understand the impact on electricity demand as a result of reduced water availability in the state in the coming years and develop new rules for the use and transfer of water. This effort is aimed at developing a clear understanding of the link between electricity use and irrigation practices under the changing rules of water consumption and environmental regulations for agricultural runoff. The report will be available in the spring of 2004.

WATER

The focus of the PIER IAW program continued to be RD&D activities that help improve the energy efficiency of processing water for urban, industrial, and agricultural consumption and the energy-efficient treatment of wastewater recovery.

PIER and American Water Works Association Research Foundation (AWWARF) conducted a
workshop to identify the energy issues and concerns facing California water and wastewater
utilities. Participants helped formulate an RD&D plan and suggested potential projects to
reduce energy costs and increase reliability. PIER and AWWARF issued a request for
proposal (RFP) to solicit projects to meet the RD&D plan.

CROSS-CUTTING INITIATIVES: ENERGY STORAGE

In addition to the sector-specific programs described above, the IAW program staff continued work on initiatives for electrical energy storage (EES) technologies that could be applied to multiple PIER program segments.

 An industrywide workshop was held to validate the status of several EES technologies and availability of vendors and ascertain that the EES technologies have indeed reached a stage where they could serve the needs of California's electrical system. • The program issued a solicitation that was aimed at the following applications:
(1) improving the operation of transmission and distribution grids by alleviating congestion or providing voltage/frequency support, (2) making renewable energy a dispatchable resource, and (3) helping with peak load reduction and load management. Three projects were selected that meet the programmatic goals of energy efficiency, peak load reduction, and California grid stability.

RENEWABLE ENERGY TECHNOLOGIES

In 2003, the PIER renewables program area awarded \$4.36 million to seven different projects, five of which are highlighted below. Other activities increased coordination with other organizations involved in RPS implementation, such as CA ISO and the Local Government Commission, and prepared solicitations planned for release in mid-2004. More than 40 percent of the awards were directed to accelerating RPS implementation in California.

- An award of \$669,000 was made to the Local Government Commission to help develop a
 technical and economic template for use in evaluating renewable energy options under a
 community choice vehicle. The template will assist local communities in evaluating possible
 pathways to using renewable energy resources under community choice aggregation to help
 meet RPS goals.
- An award of \$300,000 was made to CA ISO to help demonstrate a regional wind forecasting system under the Participating Intermittent Resource Program (PIRP), which targets the hourahead market. In addition, \$850,000 was allocated to the Electricity Innovations Institute (E2I) to continue development and verification of a California wind forecasting system that will enable both short-term (1 to 3.5 hours) and long-term (24 to 48 hours) forecasts.
- Two awards were made for renewable hardware development. The first, an award of \$725,000, was made to Community Power Corporation (CPC) to develop a second-phase small modular biomass power technology. In an earlier PIER project, CPC successfully developed and demonstrated a 12.5 kW small modular biomass power system. The first-phase unit was demonstrated at the Tsemeta Forest Regeneration Complex operated by the Hoopa tribe, showing the system had the ability to use a variety of forest residues to provide distributed generation capabilities. The second-phase system is being enlarged to 50 kW and will demonstrate the system's ability to operate within forested regions. The goal is to develop a small modular biomass power system that can help reduce wildfire risks while providing electricity at the endpoints of the distribution system.
- In the second hardware project, an award of \$1.2 million was made to PowerLight Corporation to develop an advanced tracker system for use with larger-scale PV systems. Because tracking systems enable PV systems to follow the course of the sun during the day, they allow for a greater match between peak electricity demand and the generation profile of the PV system. In the past, tracking systems have been fraught with maintenance problems and mechanical complexities. PowerLight has recently obtained patented

technology that enables multiple rows of PV modules to be mechanically connected to one drive mechanism, reducing complexity and maintenance issues. PowerLight is preparing additional significant improvements to the tracking technology that will make it more cost-effective, with increased durability for widespread use in California. If an improved tracker were successfully developed, it would enhance the peak demand and cost-effectiveness of PV programs such as the Energy Commission's Emerging Renewables program.

ENVIRONMENTALLY-PREFERRED ADVANCED GENERATION (EPAG)

The EPAG program researches, develops, and/or demonstrates a portfolio of diverse energy technologies that improve the cost-effectiveness, efficiency, reliability, and environmental performance of electric generation.

EPAG is organized into four technology areas: Advanced Turbine Technologies, Advanced Reciprocating Internal Combustion Engines (ARICE), Combined Heat and Power (CHP), and Fuel Cells and Fuel Cell Turbine Hybrids. The first three technology areas have highlights for 2003.

ADVANCED TURBINE TECHNOLOGIES

- In 2003, EPAG demonstrated a cost-effective, ultra-low-emissions, small industrial gas turbine. The project is a retrofit of a gas turbine with Catalytica Energy Systems' Xonon[®] catalytic combustor, which significantly reduces nitrogen oxide (NO_X) emissions without exhaust cleanup or toxic chemicals. The 1.4 MW Kawasaki gas turbine operates in a distributed-generation CHP application, providing electricity and steam to the 120-building State of California Sonoma Developmental Center in Eldridge, California. NO_X emissions were reduced from 30 parts per million (ppm) to less than 3 ppm using the new combustor.
- In 2004, EPAG expects to expand the application of the combustor by co-funding with the DOE, General Electric, Electric Power Research Institute (EPRI) member utilities, and others, the first demonstration of the Catalytica Xonon[®] combustion system on a popular utility-class 11 MW GE-10 gas turbine at a power plant owned by Riverside Public Utilities in Riverside, California.
- With the completion of the Sonoma demonstration and the first commercial sale of Catalytica's Xonon[®] technology, the contract stipulates that royalty payments are to be made to the PIER program; the first payment from this technology is expected in 2004.

ADVANCED RECIPROCATING INTERNAL COMBUSTION ENGINES

• In 2003, EPAG convinced DOE to adapt its Advanced Reciprocating Engines Systems (ARES) program to incorporate the stretch goals and targets of EPAG's ARICE program. EPAG and DOE jointly funded this ARICE project with the Argonne National Laboratory to develop an advanced laser ignition integrated ARICE system for distributed generation. This project is expected to beat the proposed 2007 California emission standards. Two other ARICE projects were co-funded in late 2002.

COMBINED HEAT AND POWER

- In 2003, EPAG initiated a new CHP program that identified visible examples of where and how CHP technologies can be used. The Federal Energy Management Program (FEMP) provided a grant to identify federal facilities in California that could benefit from the use of new CHP technologies. FEMP funding was also provided to select four specific facilities in California and conduct an engineering and economic feasibility analysis to justify the federal installation of CHP equipment.
- EPAG sponsored a public stakeholder process to determine the RD&D solutions needed to overcome the technology impediments preventing advanced CHP technologies from being widely used in California. This process was initiated to ensure that limited EPAG funds built on DOE and industry RD&D activities and focused on California-specific technology needs. Two public workshops were held to receive comments on the performance targets and stretch goals. A focused RFP was then released and four projects, totaling \$5.1 million, were selected in early 2004 for funding. These projects will develop a high-efficiency, ultra-low NO_X supplemental firing burner; develop a 100 kW premium power CHP module; develop an engine CHP integrated cooling and heating module; and develop an integrated microturbine generator boiler burner for packaged industrial and commercial boilers.
- A mechanism was developed to transfer the results of these and other CHP RD&D activities
 effectively to end users and the commercial market as quickly as possible. EPAG received a
 grant from DOE to establish the Pacific Southwest Regional CHP Application Center in
 California. The center, which includes Nevada and Hawaii, will conduct CHP technology
 transfer activities, including providing installation information to end users.

ENERGY-RELATED ENVIRONMENTAL RESEARCH

Through multistakeholder collaborations, PIER research identifies and addresses critical energy-related environmental problems and anticipates longer-term energy issues such as climate change before they become critical. This research supports the development of state-of-the-art monitoring, data development, modeling, and analyses that enable the state to evaluate issues and devise solutions based on factual information and sound analysis, resulting in improved regulatory decision making and informed energy policy.

The Energy-Related Environmental Research group funded numerous projects to address highpriority environmental issues related to the generation, distribution, and transmission of electricity. Two major projects focused on water modeling and avian fatality.

GLOBAL CLIMATE CHANGE: IMPLICATIONS FOR CALIFORNIA WATER RESOURCES

A rapidly growing population, decreasing freshwater supply, and changing climate may alter precipitation and runoff, increasing pressure on California's water supply. California's spring mountain runoff has decreased in recent years, and preliminary modeling suggests that the Sierra snowpack could shrink to half its size by 2060 as a result of climate change. Snowpack runoff provides much of the state's water, so decision makers need information to determine how to maintain water availability despite a changing climate.

• This project modeled a range of climate-warming estimates and their effects on the long-term performance and management of California's water system. It found that climate warming could increase water supply costs by \$1.2 billion a year, reduce hydropower by 30 percent, and reduce usable agricultural land due to water reductions. This study also identified several promising and capable adaptations to population and climate change to mitigate these problems. Project results supported the strategic planning by the California DWR and were featured in the 2003 California State Water Plan (Bulletin 160-03), a master plan developed every five years.

REDUCING BIRD FATALITIES IN THE ALTAMONT PASS WIND RESOURCE AREA

California wind turbines provide about 3 billion kilowatt-hours (kWh) of electricity to the state each year and displace fossil fuel electricity production that would otherwise produce 2.25 million tons of carbon dioxide (CO₂) emissions. However, at California's Altamont Pass Wind Resource Area (Altamont Pass), researchers estimate that more than 1,000 birds are killed annually—half of them protected raptors. Each fatality can result in fines as high as \$500,000. Moreover, these fatalities are limiting the construction and repowering of wind facilities in California.

• In this project, researchers are surveying portions of the Altamont Pass; investigating the effects of the turbine design, topography, and land management on collision risk; and developing a model that will identify and reduce avian collision risk. Researchers are identifying and assessing the significance of risk factors, and the model will be based on the statistical importance of these factors. A previous study found that only 25 percent of the Altamont Pass turbines were responsible for all of the avian fatalities in the study year. Fatalities could be reduced significantly by investigating this fact. A successful outcome could reduce the incidence of illegal bird kills, increase generating capacity at the site, and contribute to state goals for renewable energy use.

ENERGY SYSTEMS INTEGRATION (ESI)

The ESI team looks at California's electricity system's challenges and sees many opportunities for improvement. ESI views the electricity system from an integrated *systems* perspective—seeking opportunities to address integration, foster enabling technologies, and address gaps in the PIER portfolio. Three examples include enabling DR, integrating distributed energy resources (DER), and improving resiliency and flexibility in the transmission system.

DEMAND RESPONSE

California's electricity transmission and distribution system exists to satisfy consumer loads. Though the system is "smart", the loads are not. Our electricity system must constantly react to loads rather than the loads responding to the system's conditions. Demand response is about making the loads "smart" so that they can and will respond dynamically to system conditions—adjusting automatically when prices are too high or supplies are constrained. Highlights include the following:

- DR research is underway at University of California (UC) Berkeley that has the potential to dramatically reduce the costs of deploying a DR infrastructure. The university is leveraging previously developed advanced technologies (such as Pico radios, Smart Dust, and TinyOS) and exploring innovative ways to integrate them into common devices such as home thermostats and electric meters. After six months of work, the research team has met its initial cost-reduction targets for the Pico radio—critical to reducing communication costs.
- Lawrence Berkeley National Laboratory (LBNL) tested the ability of five large commercial
 facilities to shed load automatically in response to a dynamic price signal. All facilities, with
 different monitoring and control systems, successfully responded and automatically shed
 load. The results are being further analyzed to determine the amount and character of the
 load shed.

INTEGRATING DISTRIBUTED ENERGY RESOURCES

DER is defined as local distributed generation storage or responsive load that is interconnected with the utility power system and enables customers to reduce energy costs and improve their electricity reliability. Since the energy crisis in the winter of 2000–2001, the number of DG projects being interconnected has continued to rise at roughly 29 percent a year, equating to over 370 MW of new DG capacity. This trend is anticipated to continue.

The ESI strategy to enable DER is threefold. First, research and policies are being implemented to interconnect DER so that today's power system is not harmed. Second, research is being conducted and policies developed to understand how much DER the power system can absorb before its reliability is detrimentally impacted. Third, novel and innovative concepts are being investigated for designing power systems of tomorrow that will enable two-way power flow so that DER can provide benefits to the power delivery system. Highlights include the following:

- Research was initiated to test the positive and negative interactions of high penetration
 of DER with the electrical utility grid at the recently commissioned Distributed Utility
 Integration Test (DUIT) facility in San Ramon. This project addresses issues critical to
 removing barriers that prevent DER from becoming a significant energy resource for
 California by providing neutral analysis on topics such as anti-islanding and voltage stability.
- The California Interconnection Guidebook: A Guide to Interconnecting Customer-owned Electric Generation Equipment to the Electric Utility Distribution System Using California's Electric Rule 21 (P500-03-083) was published to help developers and utility customers understand the requirements and processes associated with interconnecting distributed energy resources in accordance with Rule 21.

IMPROVING TRANSMISSION RELIABILITY AND CAPACITY

Although new power plants have been built in California and throughout the WECC, we do not have enough transmission capacity to move this power to where it is needed. In fact, there are transmission bottlenecks in California that threaten electricity supplies of entire geographic areas, such as the San Francisco peninsula. Solving these problems will be a long-term effort

because new transmission lines are very slow to get regulatory approval and are extremely expensive to build. ESI is developing solutions to these problems by implementing a twofold strategy: develop techniques and technologies that will squeeze more capacity out of our existing transmission infrastructure; develop the tools and hardware that will help California develop adequate transmission capacity within the next ten years. Highlights include the following:

- A five-year transmission research plan was developed to focus on the highest public interest transmission issues. It will be used to guide and coordinate the program's research activities.
- The Sagging Line Mitigator (SLiM) project was completed. It successfully designed, developed, and demonstrated hardware to prevent sagging of transmission lines. SLiM's key component is a nickel-titanium shape memory alloy that reacts to increasing conductor temperature by mechanically decreasing line sag. The benefits are many: increased line capacity, delayed need for new transmission lines, and increased public safety by reducing wildfires and blackouts caused by trees in contact with transmission lines.
- Two real-time monitoring systems for overhead transmission lines were successfully designed, developed, and demonstrated. This information allows system operators to monitor the physical limitation of these lines (sag) and operating limits so that they can better detect and manage contingency situations. One technology utilizes a machine vision-point source to monitor ground clearances and sags from remote locations. Another technology uses dynamic sensors to monitor temperature. Both systems have been installed and tested to measure, in real time, the line capabilities of transmission lines in critically constrained areas in the state. The potential benefit to the California public is a 20 percent improvement in the transmission efficiency of existing lines that are limited by ground clearances.

ENERGY INNOVATIONS SMALL GRANT (EISG)

The EISG program is designed to tap the innovativeness of small businesses, inventors, and academic faculties for new energy technology concepts that would not necessarily receive attention from the traditional RD&D community. It competitively selects concepts that can address California's energy challenges and priority issues in new, more effective ways. The program operates at the very entry point between raw ideas and traditional RD&D programs that make up the bulk of the PIER program. By testing and verifying the feasibility of new concepts, the program creates new technology development opportunities not previously available to energy RD&D.

The program is competitive and, through three solicitations a year, provides grants up to \$75,000 to prove the feasibility of concepts most likely to lead to the best research success. Approximately 30 one-year grants are awarded annually. Over 90 percent of the follow-on RD&D funds are being spent in California. At this time, we use two measures to judge EISG program success:

- Success in proving the feasibility of new concepts: A 2003 survey of completed grant projects showed that 50 percent of the 50 completed projects had verified their concepts sufficiently to capture follow-on RD&D funding from new funders. The follow-on RD&D funding totaled \$40 million, or 11 times the \$3.5 million in grants originally awarded to the 50 completed grant projects.
- Credible decision makers: The new players who saw real potential in further development
 of the concepts were credible decision makers, such as electric utilities, the DOE, the
 National Science Foundation, National Aeronautics and Space Administration, and venture
 partners. The PIER program also selected some of the completed grant projects for further
 development.

CHAPTER 4

program SUCCESSES = BENEFITS for california

BENEFITS FROM PIER COMMERCIAL SUCCESSES

The PIER program began in 1998. Because the average time from start to finish for a research project is slightly over three years, some commercially promising products, processes, techniques, and information items (collectively, products) are just beginning to emerge.

At this time, PIER evaluates the potential benefits of these emerging products based on projected sales or applications of these products during their first five years of commercial availability. When actual sales and application histories are available, we will use them in the analysis. The benefits are based on side-by-side comparisons of the products and their likely competitors in the market, and a net present value is calculated for the cash flow stream over the economic lifetimes of the products sold during the initial five years. The present values are based on reduced energy costs, reduced operating costs, or avoided or deferred capital expenditures.

Other benefits, not quantified by this method, will also accrue to Californians. These benefits include increased jobs and economic activity from the manufacture of products in California, a healthier environment as a result of emissions reductions, and improved performance and reliability of the electricity system from products that reduce the consumption or improve the transmission and distribution of electricity.

EMERGING PRODUCTS AND TECHNOLOGIES: UPDATE ON 2002 SUCCESS STORIES

Through 2002, 20 products were successfully commercialized and were expected to produce net life-cycle benefits between \$221 million and \$576 million for their users as a result of sales projected during the first five years of commercial availability. Based on PIER

2003 PIER ANNUAL REPORT 25

program disbursements through 2002, the benefit-to-cost ratio was between 2 to 1 and 5 to 1. The range of benefits reflects uncertainties in the performance and sales projections for the products. (Endnote 15)

Nineteen of these products are shown in Table 1 (Endnote 16). The sluggish economy has slowed the pace of introduction of some of the products (e.g., Berkeley Lamp, Cast Metal Industry Electricity Consumption Study, NOx Control in Biomass-Fueled Boilers with Natural Gas Cofiring), but that pace is expected to increase as the economy recovers.

Table 1 PIER RD&D Products Commercialized Through 2002

Residential and Commercial Buildings End-Use Energy Efficiency

Berkeley Lamp

Commercial Kitchen Ventilation

Particulate Emissions Measurement for Unhooded Restaurant Appliances

Revised Residential Framing Factors

HVAC Duct Sealing Technique for Small Commercial Buildings

Allowable Placement of Roof/Ceiling Insulation in Nonresidential Buildings

Requirements for Skylight Use in Low-Rise Residential Commercial Buildings

Goettl Comfortquest Gas Heat Pump

Real-Time Energy Management and Control Systems

Industrial/Agricultural/Water End-Use Energy Efficiency

Cast Metal Industry Electricity Consumption Study

Renewable Energy Technologies

 NO_X Control in Biomass-Fueled Boilers with Natural Gas Cofiring PowerGuard $^{\circledR}$ Solar PV System for Flat Roofs

Environmentally-Preferred Advanced Generation

Catalytica Xonon® Catalytic Burner

Energy-Related Environmental Research

Low NO_× FIR Burner for Gas Boiler

Energy Systems Integration

DG Interconnect Hardware

Real-Time Monitoring and Dynamic Rating System for Overhead Transmission Lines Interconnection Standards for Small Distributed Generators

Improved Substation Seismic Design

Required Utility Buildings Seismic Vulnerability

These early PIER results compare favorably with results reported by other RD&D organizations with similar mandates, such as the Gas Research Institute, the EPRI, the New York State Energy Research and Development Administration, and the DOE. These four organizations are generally regarded as quite successful in fulfilling their mandates. Their records of success are not only good yardsticks to compare PIER's successes, but also serve as good benchmarks against which PIER can continue to measure future success. Table 2 summarizes the benefit-to-cost ratios reported by these organizations, together with the reported PIER results.

Table 2 Benefit-to-Cost (B/C) Ratios Reported by PIER and Similar Organizations

ORGANIZATION	REPORTED B/C RATIO
Gas Research Institute	Range from 4:1 to 9:1
Electric Power Research Institute	Range from 1.5:1 to 5:1
New York State Energy Research and Development Administration	3:1 (estimated)
U.S. Department of Energy	4.3:1
PIER	Range from 2:1 to 5:1

PIER PRODUCTS PLACED INTO COMMERCIAL USE IN 2003

Twenty-three new products emerged from the RD&D cycle in 2003. The benefits of these products have not yet been evaluated, but an analysis will be completed and published by mid-2004. Summaries of each of the 23 products are presented below.

RESIDENTIAL AND COMMERCIAL BUILDINGS END-USE ENERGY EFFICIENCY

 Two-Stage, Indirect-Direct Evaporative Cooling (IDEC) System. Developed by the Davis Energy Group, this unit is more reliable, less costly, and more efficient than the previous SmartCool models. This IDEC system has annual energy savings of 89 to 95 percent over conventional cooling systems and a peak load reduction of 80 to 89 percent for typical California use. Davis Energy has received a letter of intent from an experienced manufacturer for licensing the technology. We will track its market acceptance over the next few years.

URL: http://www.davisenergy.com/pdf/IFSo6o3.pdf

• Cal-Arch Energy Benchmarking Tool. This web-based software tool includes databases, analysis techniques, data definitions, and performance metrics to reduce building energy usage and cost. The Cal-Arch tool allows a commercial building operator to compare his or her building's energy use to the energy use of other buildings of similar size and location via a web-based application. This free software is available on-line today.

URL: http://poet.lbl.gov/cal-arch/benchmark.html

• Hotel Bathroom Motion Sensor Nightlight. LBNL has documented the performance of a new lighting control system for bathrooms of existing hotels. In addition to conventional bathroom lighting, the WN-100 Motion Sensor Nightlight control system incorporates a motion/timeout sensor calibrated toward bathroom usage times and an automatic LED nightlight. Testing was conducted at the DoubleTree Hotel in Sacramento, where researchers confirmed a 46 percent reduction in bathroom light usage and a 40 percent drop in peak load usage when compared to conventional light switch usage. The WN-100 Motion Sensor Nightlight can be purchased from The Watt Stopper.

URL: http://www.wattstopper.com/products/details.html?id=96

• **Bi-level Stairwell Fixture**. This project characterized the performance of and identified California code issues associated with a new bi-level light fixture developed by OccuSmart for stairwells, restrooms, laundry rooms, and other areas that require full lighting when occupied and minimal lighting when unoccupied. The fixture is a T8 lamp with the ability to provide 100 percent, 33 percent, 10 percent, and 5 percent output intensities. It is activated by an integrated ultrasonic motion sensor and has the potential to greatly reduce building energy consumption as well as peak energy demand. OccuSmart is currently selling three model types and a total of seven different variant products.

URL: http://www.occusmart.com

Advanced Variable Air Volume (VAV) System Design Guide. The design guide addresses the
air side of built-up VAV systems in commercial buildings larger than 100,000 square feet. It
was developed to promote efficient, practical, VAV system designs that advance standard
practice, minimize life-cycle cost, and can be successfully implemented today. For buildings
adopting the practices in the design guide, we estimate potential HVAC electricity savings of
25 percent, corresponding to 12 percent of total building electricity consumption. This guide
has been disseminated to designers and manufacturers of large HVAC systems.

URL: http://www.newbuildings.org/pier/downloadsFinal.htm

- Small Commercial Heating, Ventilating, and Air Conditioning System Design Guide. These guidelines recommend actions that architects, engineers, and design/building contractors can take to improve the energy efficiency of small HVAC systems, reduce operating costs, and improve indoor comfort and environmental quality. Researchers estimate that HVAC system operational losses could be reduced by 20 to 30 percent statewide if recommendations in this design guide were followed. This free guide is available on-line. URL: http://www.newbuildings.org/pier/downloadsFinal.htm
- Design Guidelines for Skylights with Suspended Ceilings. These design protocols facilitate
 the use of skylights in buildings with suspended ceilings to minimize energy use while
 meeting all building requirements, such as fire protection, seismic safety, and acoustics.
 Following these guidelines will result in skylight/light-well systems that provide optimal
 energy performance and superior lighting quality. This free guide is available on-line.
 URL: http://www.newbuildings.org/pier/downloadsFinal.htm

INDUSTRIAL/AGRICULTURAL/WATER END-USE ENERGY EFFICIENCY

- Selective Tartrate Removal System. The Selective Tartrate Removal System (STARS), developed by Eurodia Industrie S.A., uses an electrically driven membrane process to stabilize potassium and calcium tartrates during the wine-making process. It has the potential to supplant traditional cold stabilization methods used throughout the wine and juice industries. The STARS system has demonstrated an 80 percent reduction in energy use, compared to traditional tartrate stabilization processes, and is being evaluated by one small California winery. Both stationary and mobile units can be obtained from Winesecrets. URL: http://www.winesecrets.com/
- Neutral Line Filter for Harmonics Reduction. Switching power supplies, such as those found in most computers and data centers, create harmonics that travel throughout a building's electrical distribution system, causing excessive power consumption in motors found elsewhere in the building. In turn, this excess consumption leads to overloads in the building's wiring and transformers. The EPRI Power Electronics Applications Center demonstrated that a harmonic filter installed in the neutral line of a three-phase power circuit in a Sacramento facility belonging to the California Franchise Tax Board could substantially reduce the harmful effects of the harmonics, reduce the air conditioning load, and reduce energy use by 4 to 6 percent. Based on the results of this demonstration, customers can confidently use the filters available from several vendors.

 URL: http://www.energy.ca.gov/pier/factsheets/2003-12_FACTSHEET_HARMONIC.PDF
- Industrial Compressed Air System Energy Use Benchmarking Methodology. Compressed air is the fourth largest utility cost (after electricity, natural gas, and water) in industrial operations. While air compressor efficiencies are well documented, energy use for the entire compressed air system (compression, storage, and distribution combined) is poorly understood. SCE successfully developed a method to determine compressed air system energy consumption and a way to compare it to best practices. This benchmarking methodology has been demonstrated at five sites in SCE's service area and will be demonstrated in the service area of another California electric utility in early 2004. As a result, SCE has developed an energy auditing program for compressed air systems that it proposes to implement under its Public Goods Charge Energy Efficiency program, pending approval by the CPUC. If approved, customers will receive rebates for implementing recommendations contained in their audits.

URL: http://www.energy.ca.gov/pier/indust/descriptions/500_01_026.html

RENEWABLE ENERGY TECHNOLOGIES

Clean Power Estimator. The Clean Power Estimator, developed by Clean Power Research,
LLC, provides California residential and commercial electric customers a personalized
estimate of the costs and benefits of investing in a PV or small wind electric generation
system. PIER funded the development of a module for this software program that compares
alternate roof options such as the addition of a radiant barrier, the use of high reflectivity
materials (cool roof concept), or the use of roof systems with integrated PV cells. The
software takes into consideration customer-specific information, such as location and

electric rates, and provides an estimate of the costs and benefits of a PV or wind system. This web-based economic evaluation software, with the new module, is available from the Energy Commission.

URL: http://www.consumerenergycenter.org/renewable/estimator/index.html

• Evaluation of the Utility System Capacity and Customer Demand Values of Photovoltaic Systems. This report summarizes the benefits accruing to a utility from either utility or customer ownership of PV systems. The study evaluated benefits arising from reduced energy use; reductions or delays in the need for new transmission and distribution facilities; reduced exposure to volatile fuel prices; reduced emissions of criteria air pollutants; local capture of state, federal, or government incentive payments; and the creation of new business opportunities for the utility. By evaluating multiple scenarios and ranges of possible benefits for each metric, the report helps utilities identify market niches to implement PV systems profitably for both the customer and the utility, thus helping to encourage the market for PV systems. This report, prepared by Clean Power Research, LLC, is available from the Sacramento Municipal Utility District.

URL: http://www.smud.org/pier/reports/S-034,%201.3.5.2,%2012-02,%20DEL(rev).pdf

• PV Mounting Approach for Flat Roofs. The SunRoof™ FS system has no roof deck penetrations and, as a result, can be installed faster than competing systems, can be installed around roof objects, and can be tilted to increase electricity production. Furthermore, the system consists of interlocking panels that make it highly resistant to wind or earthquake damage, and it has a 25-year design life that meets or exceeds all industry standards. This competitive solution for PVs in the flat roof commercial market is now offered by RWE-Schott Solar.

URL: http://www.rweschottsolar.com/cms/us/(nga20045fky15avrpnjd0055) /webseite.aspx?navid=136

• Solar Power Integrated Roof Tile. One way to lower the costs of PV systems is to incorporate them into structural components such as the roof. The APi-o55 GECKO™ roof tile with integrated PV cells generates peak power of 55 watts at 8.4 volts. The tiles are manufactured to integrate seamlessly with MonierLifetile, Hanson, or Eagle Roof tiles, which are commonly used for residential roof applications. The tiles have a 25-year limited warranty on materials and workmanship. A home builder has announced plans to include the tiles as a standard feature in one development in the Sacramento area. The tiles are available from AstroPower, Inc.

URL: http://www.astropower.com/api-55-gdatasheet.pdf

• California Wind Energy Collaborative. The California Wind Energy Collaborative (CWEC), established at UC Davis in 2002, provides a California perspective that complements the nationally focused efforts of the American Wind Energy Association, the DOE National Wind Energy Program, and the NREL. Activities undertaken to date include research, development, system deployment, technical training, and technology and resource assessments. Major contributions of CWEC through the end of 2003 include (1) the

establishment of a physical focal point for wind-energy-related activities in California; (2) the development and maintenance of the California Wind Performance Reporting System, which tracks electricity capacity and production from wind as well as available technology; (3) the development of a statewide wind-engineering technician training program; and (4) a series of papers to evaluate wind resources and electric generation capabilities in California. URL: http://cwec.ucdavis.edu

• California Wind Energy Resource Mapping. The purpose of this project was to encourage the development of wind energy in the state by helping companies and individuals identify promising wind project sites with minimal effort. To do this, TrueWind Solutions, LLC developed a set of high-resolution maps of California that display annual and seasonal averages of wind speed and wind power density on a 200 meter grid. These wind resource maps are available in hard copy from the Energy Commission Cartography Office or electronically in JPG format on the Energy Commission website. In addition, an electronic interactive version is available, as are data sets that can be accessed through a geographic information system application.

URL: http://www.energy.ca.gov/maps/wind.html

• California Biomass Collaborative. The California Biomass Collaborative was established in 2003 to enhance the development of sustainable and effective biomass energy systems for the State of California. The collaborative is undertaking activities to research, develop, demonstrate, and deploy systems, as well as education and training, complementing the activities of the California Biomass Interagency Working Group. In addition to providing a focal point for biomass research activities in California, the collaborative has initiated the development of the Biomass Facilities Reporting System to track biomass electricity capacity and production and has distributed surveys to facility owners/operators. A series of resource and technology assessments are envisioned in the near future. URL: http://biomass.ucdavis.edu

ENERGY RELATED ENVIRONMENTAL RESEARCH

• Bird Fatality Reduction Methods in the Altamont Pass Wind Resource Area. Because of the numbers of fatalities of such birds as golden eagles, red-tailed hawks, burrowing owls, and other raptors, legal requirements and possible legal actions threaten the continued operation of approximately 530 MW of wind power in the Altamont Pass as well as the potential for 300 MW of additional capacity. The Energy Commission developed a risk sensitivity model for the wind industry to use to help reduce bird fatalities from collisions with wind turbines. Research results that relate site, turbine, and management conditions to expected bird fatality rates have been presented to the wind operators, the U.S. Fish and Wildlife Service, and the California Department of Fish and Game. The researchers also recommended actions to reduce the number of fatalities and monitoring programs to verify the effectiveness of the recommendations. These recommendations will inform the development of a mitigation plan being prepared by the wind industry and reviewed by the U.S. Fish and Wildlife Service.

URL: http://www.energy.ca.gov/pier/energy/project_fact_sheets/500-01-019.html

• Global Climate Change Study: Impacts of Global Climate Change on California.

Researchers from EPRI, Stratus Consulting, Inc., and Yale University have prepared a report examining the likely impacts for a range of climate change scenarios over the next century. Impacts included changes in precipitation and precipitation patterns, forest growth, habitats for California wildlife, energy use, coastal flooding, and human health. The California Department of Water Resources participated in the study. As a result, DWR's draft 2003 five-year plan explicitly recognizes the importance of climate change as an issue in future water resource planning. The program is currently developing probability-weighted, alternative climate change scenarios that DWR intends to use extensively in the ongoing preparation of its 2008 five-year plan.

URL: http://www.energy.ca.gov/pier/reports/500-03-058cf.html

ENERGY SYSTEMS INTEGRATION

• Real-Time Dynamic Rating System for Electrical Transmission Lines. Frequently, the rated maximum allowable current flow through a transmission line is determined by line expansion, sag, and the resulting clearance between the line and the ground or other objects. However, this rating method is generally quite conservative, underestimating the electricity that can actually be transmitted over that line. EDM, Inc. developed a system that monitors the position of a specific segment of a transmission line and uses that information, together with measures of environmental conditions, to calculate a real-time current rating for the line. If used, this technology will allow additional electricity to be transported over critical transmission lines during periods of peak demand. Benefits include deferral of new transmission lines and opening additional transmission paths during peak periods, increasing electric system reliability. The system was tested on a segment of SCE's transmission system, where it performed as expected. This system is being sold by EDM, Inc.

The next three projects are part of a set of tools being developed by CERTS to improve the management of the WECC electricity system. The CA ISO is active in the design and testing of these tools and plans to use these tools to better manage electricity flows throughout its system.

- CERTS Volts Amps Reactive (VAR) Voltage Management Tool. This tool replaces difficult-to-read and time-consuming tables of voltages at each monitoring point within the system with a visual, bird's-eye view of the overall health of the grid. Reliability coordinators and system operators get immediate access to critical information on system voltages over a wide area. This addresses a key problem facing operators today—data overload—and enables operating margins to be managed more effectively and reliably. The tool has been installed at both the Folsom and Alhambra CA ISO control centers and is being expanded to encompass the entire CA ISO system.
 URL: http://www.energy.ca.gov/reports/2003-11-21_500-03-087F.PDF
- CERTS Control Area and Supplier's Performance for Automated Generation Control (AGC) and Frequency Response Services System. Today, reliability coordinators can identify control areas that are causing dangerous frequency excursions and notify

dispatchers in these control areas in near real time so that they can take corrective action. The CERTS Control Area and Supplier's Performance for AGC and Frequency Response Services System allows the control area dispatchers to pinpoint the individual suppliers or reserves (i.e., generators) within their control area that are deviating from their operating commitments and therefore causing the frequency excursions, rather than relying on delayed notification from the reliability coordinators. Using this tool, control area dispatchers can now notify these suppliers immediately and initiate additional remedial actions to maintain electricity supply reliability. This tool was delivered to CA ISO dispatchers in 2003, and the CA ISO operations staff is considering its implementation. URL: http://www.energy.ca.gov/reports/2003-11-21_500-03-086F.PDF

CERTS Monitoring Applications Based on Synchronized Phasor Measurements.
Conventional grid monitoring technologies take snapshots of the state of the system every four seconds. However, reliability-threatening transient phenomena can occur over much shorter time scales. This technology, developed by CERTS, records observations many times per second, providing grid operators with this data in real time so that they can obtain a more accurate picture of the actual health of the grid. The CA ISO is pioneering the application of this phasor technology, with the expectation that this technology will improve their ability to maintain a reliable system.
URL: http://www.energy.ca.gov/reports/2003-11-21_500-03-088F.PDF

CHAPTER 5

PLANS for 2004

RESIDENTIAL AND COMMERCIAL BUILDINGS END-USE ENERGY EFFICIENCY

Although California's energy industry has stabilized, Californians still need new energy innovation to provide them with the most effective tools and technologies to address future energy shortages or price increases. In 2004, the PIER buildings program will initiate several new collaborative projects to address current customer issues related to the state's energy situation. Major initiatives planned include the following:

DEVELOPMENT OF CALIFORNIA-OPTIMIZED AIR CONDITIONER

Residential and commercial air conditioners consume between 12 and 16 percent of annual electricity use in California and approximately 30 percent of peak demand. This project develops an air conditioner for California and other hot/dry climates that is energy-efficient under high-temperature, low-humidity conditions. This technology will contribute to lower peak demand, lower utility bills, and a more reliable electricity system. Efficiency improvements are expected to be as high as 20 percent or more above current market units.

COMMISSIONING, DIAGNOSTICS, AND CONTROLS—MARKET PRODUCTS

Over 28 percent of the electricity used in California commercial buildings is for air conditioning, heating, or ventilation.

Approximately 10 to 40 percent of this energy is wasted, due to excessive run times and undetected problems with HVAC equipment or controls. This project will develop tools to save energy, improve equipment reliability, and reduce operating costs via final development on a number of fault-detection tools and diagnostics. The research team will work with industry to embed these

2003 PIER ANNUAL REPORT 34

diagnostics into commercial equipment. At the end of this project, a next generation of packaged and built-up HVAC equipment with integrated diagnostics will be developed to allow facility management staff to identify problems that cause system inefficiencies.

REDUCING STANDBY POWER IN ELECTRONIC EQUIPMENT

The amount of electronic equipment in homes and businesses has increased manyfold in recent years. This trend continues to grow as the use of electronic equipment that is both higher in power (larger TVs) and more numerous (e.g., digital set top boxes, home computer networking) continues to expand. Initial studies from the Natural Resources Defense Council indicate that electronic equipment standby energy uses about 10 percent of residential electricity consumption. A solicitation is planned that will fund projects to develop and facilitate the early market adoption of electronic equipment that is more efficient in both the active and standby modes.

CALIFORNIA LIGHTING TECHNOLOGY CENTER

This contract will establish a lighting research center in California, resulting in the development of more energy-efficient lighting products for the state's consumers and more lighting businesses focusing on the California market. The result will be greater consumer choices for lighting products, which will reduce energy bills, and a stronger business climate for the state's lighting industry.

DEMAND RESPONSE RESEARCH CENTER

Demand responsive strategies are rapidly being deployed in California and elsewhere in the nation. However, many questions regarding DR-related technologies, controls, utility program designs, tariffs, and consumer behavior remain unanswered. In addition, while the approach appears promising, many of the tools and controls needed for optimizing demand responsiveness in buildings are not yet available. The PIER buildings program is collaborating with the PIER Energy Systems Integration program to initiate a center that will create a hub in California for DR-related research that will begin to answer these questions, fill technology gaps, and enable seamless sharing of new information. It will also provide a central point of new information dissemination to policy makers and others to enable them to make the best and most informed decisions in this area.

INDUSTRIAL/AGRICULTURAL/WATER END-USE ENERGY EFFICIENCY

The IAW program will continue to fund projects in accordance with an 18-month budget approved by the Energy Commission's RD&D Committee. Specific RD&D opportunities will be selected in accordance with the sector's specific plans, developed in collaboration with end users, stakeholders, and other institutions engaged in similar research.

IRRIGATION SECTOR RD&D PLAN

An RD&D plan for energy savings and cost reduction in the irrigation sector will be developed. The document will be produced in collaboration with agricultural electricity customers, utilities and irrigation districts serving them, and other stakeholders. Implementation of the plan should begin by summer 2004.

PETROLEUM REFINERY RD&D PLAN

The IAW program will complete an RD&D road map currently funded under a grant from the DOE for the petroleum refining industry in California. The petroleum refining industry consumes the most electricity of all the industrial energy users in California.

FOOD PROCESSING AND REFRIGERATED WAREHOUSE RD&D

Several of the food processing RD&D projects resulting from the June 2003 solicitation should be completed and ready for technology transfer. The Food Industry Energy Research program will begin a new initiative aimed at refrigerated warehouses, because they are a prolific user of electricity in California and offer a significant opportunity for energy efficiency.

DEMAND RESPONSE AND CROSS-CUTTING ELECTRICAL ENERGY STORAGE PROGRAM

The program will continue focusing on projects that facilitate industrial/agricultural electricity user participation in demand response and real-time pricing programs in coordination with the broader Energy Commission activities in this area. In addition, electrical energy storage projects that cut across several PIER programs will be funded and initiated.

WATER AND WASTEWATER ENERGY EFFICIENCY PROJECTS

This program will continue implementing the water and wastewater energy efficiency RD&D plan and specific projects that were identified in collaboration with the California water utilities and AWWARF. Although the initial focus would be on potable water projects, the focus in coming months would gradually shift to wastewater RD&D projects.

RENEWABLE ENERGY TECHNOLOGIES

In accordance with an 18-month budget approved by the Energy Commission's RD&D Committee, a number of solicitations are underway in the PIER renewables area. The solicitations include the following:

LOWER-COST WIND TURBINES

A \$4 million targeted wind solicitation for lower-cost wind turbines capable of operating in low-wind-speed regimes will be initiated.

ZERO-ENERGY HOMES

A joint solicitation with the Residential and Commercial Buildings End-Use Energy Efficiency PIER area on developing cost-effective, zero-energy homes targeted to California's needs will be developed.

SMALL MODULAR BIOMASS SYSTEMS

A \$2 million targeted solicitation on developing small modular biomass systems capable of handling a variety of forestry and urban residues, and acting as clean and cost-effective DG systems, will be conducted.

REDUCED GEOTHERMAL EXPLORATION AND DRILLING COSTS

A \$4 million joint solicitation with the Geothermal Resources Development Account program will

be conducted to focus on reducing geothermal exploration and drilling costs in California and establishing a California Geothermal Energy Collaborative and a California Renewables Electricity Service Providers Collaborative.

SOLAR ELECTRICITY LONGER-TERM DEVELOPMENT

A solicitation focused on longer-term development of breakthrough technologies in the solar electricity arena will be initiated.

ADVANCED RENEWABLE ENERGY TECHNOLOGIES

The renewables area will begin coordinating the implementation of advanced renewable energy technologies and services in the Hetch Hetchy/San Francisco region.

ENVIRONMENTALLY-PREFERRED ADVANCED GENERATION

During 2004, EPAG will focus its new activities on co-funding demonstrations of several successful 2003 research projects. These demonstrations are the next necessary steps that will enable the technologies to enter into the commercial marketplace, thereby providing public interest benefits to Californians. EPAG will also become increasingly involved in providing technical assistance and coordination in the development of hydrogen technologies.

FIELD DEMONSTRATION OF THE SOLAR TURBINES MERCURY 50, A LOW-EMISSIONS, HIGH-EFFICIENCY INDUSTRIAL GAS TURBINE REQUIRING NO EXHAUST GAS CLEANUP

This project will be the first commercial demonstration of the Mercury 50, a 4.6 MW gas turbine designed and manufactured by Solar Turbines Inc. of San Diego. The site will be a hospital near San Diego. Development of the Mercury 50 has proceeded under the DOE Advanced Turbine Systems program since 1995, and has resulted in an innovative design that is highly efficient and cost-effective and that produces very low NO_X emissions without catalytic combustion or exhaust cleanup. Novel technologies in this turbine have raised efficiency to 38.5 percent. The Mercury 50 is expected to meet ARB's proposed 2007 emissions standards.

DEMONSTRATION OF A 5 MW ZERO-EMISSIONS GAS-FIRED POWER PLANT WITH EFFICIENT SEPARATION OF CO₂ FOR SEQUESTRATION OR ENHANCED OIL RECOVERY

With leap frog funding from EPAG and DOE, as well as from private investors, Clean Energy Systems (CES), a small Sacramento company, has developed a novel combustion system based on rocket engine technology. Exhaust from the combustor is a mixture of $\rm CO_2$ and steam only, driving a steam turbo generator to generate electricity. There are no emissions of regulated pollutants. The steam is condensed and recycled through the system, so no external water is needed to operate the power plant. The $\rm CO_2$ is efficiently separated to sequester in a deep aquifer or to deliver to oil fields for enhanced oil recovery.

The development of this clean generation technology is progressing in the EPAG program, but also supports PIER environmental program efforts to address global warming by reducing the release of CO_2 from power plants. Before the end of 2004, CES expects to demonstrate the technology and generate 5 MW of electricity at its test facility near Bakersfield, California.

FIELD DEMONSTRATION OF THE ARICE WAUKESHA ENGINE

This field demonstration follows the successful completion of the engine's endurance test for over 600 hours in 2003. During the endurance test, the engine achieved 37.5 percent efficiency and less than 0.001 gram/brake horsepower-hour (g/bhp-hr) NO_X emissions, surpassing the California 2007 proposed emission standards. A 4,000-hour field demonstration will be conducted during 2004. Also during 2004, Waukesha will finish their second engine and complete its endurance test for over 600 hours, with a targeted efficiency of 42 percent and less than 0.001 g/bhp-hr NO_X emissions.

Additionally, a national conference on advanced reciprocating engine RD&D will be conducted in Sacramento in April 2004. This conference will be funded by DOE's ARES program and will bring additional recognition to the ARICE program and DG siting issues in California.

FUTURE HYDROGEN INFRASTRUCTURE DEVELOPMENT

EPAG has emphasized two of the four major aspects of a hydrogen infrastructure; namely, hydrogen production and use, especially in higher temperature fuel cells. The other two aspects, hydrogen storage and distribution, are of greater importance in transportation applications than in stationary electricity generation applications and are not currently part of EPAG's plans.

EPAG will continue to provide its technical expertise and experience to develop nationally accepted DG performance testing and reporting protocols to relevant state programs, such as the California Stationary Fuel Cell Collaborative, and to national programs, such as the DOE's Solid State Energy Conversion Alliance and the Association of State Energy Research Technology and Transfer Institutions. EPAG will also participate in the Gas Technology Institute and the EPRI technology evaluation and demonstration projects. These projects measure the technological and economic performance of today's hydrogen-related technologies and identify institutional and technical barriers to their widespread use.

ENERGY-RELATED ENVIRONMENTAL RESEARCH

In 2004, the Energy-Related Environmental Research program area will continue to address issues identified in the *PIER Environmental Area Research Plan*, in specific subject area research road maps and in the *PIER Climate Change Research Plan*.

AQUATIC RESOURCES RESEARCH

Research in this area will focus on the environmental, economic, and energy aspects of managing the state's water supply; a coupled atmospheric, terrestrial, and groundwater modeling system; alternative power plant cooling technologies; the environmental impacts of hydropower generation; and efforts to improve water runoff prediction and reservoir decision management.

• The Ecological Effects of Pulsed Flows on Aquatic Communities

To prevent blackouts during peak demand periods, hydroelectric plants can discharge water to generate electricity almost instantaneously. However, abrupt and abundant releases of water from hydropower plants (i.e., pulsed flows) affect aquatic habitats and organisms that

live in the recipient water bodies. Uncertainty about how specific flows affect aquatic habitats and their inhabitants makes it difficult for hydropower plant operators and regulators to balance flows to protect native and recreational fisheries while maximizing power production. Moreover, about 150 California hydropower facilities are scheduled for Federal Energy Regulatory Commission relicensing over the next 15 years, and most of those facilities were built prior to current environmental regulations. Better data and analysis is needed if new licenses are to support a healthy balance of hydropower capacity, operational flexibility, and aquatic habitat protection. This project is working to increase the understanding of the dynamics between pulsed flows and aquatic habitat health.

LAND USE AND HABITAT RESEARCH

Research efforts in land use and habitat will focus on the biological issues of siting and managing transmission line right-of-ways, avian electrocution and collisions with transmission lines and wind turbines, and assessing environmental impacts of nitrogen deposition.

• A Life-Cycle Assessment of Wildland Biomass for Electric Power

The Southern California wildfires in late 2003 highlighted the problem of forest fires in the state, spurring increased interest in removing excess biomass from California's wildlands. Some of that biomass could be used to produce renewable electricity. However, long-standing disputes about the environmental and economic benefits of using wildland biomass for electricity production remain largely unresolved, as do the amounts of biomass to remove, optimal removal methods, and the best approaches to mitigate impacts to species or habitat. This project is developing a life-cycle assessment model that will help foresters assess the environmental and economic life-cycle impacts and benefits of using forest-derived fuels for biomass power. It will also help determine the best thinning treatments to promote forest health.

AIR QUALITY RESEARCH

Air quality research will focus on conducting life-cycle analyses of distributed generation, modeling to reduce effects of urban heat islands, and identifying relationships between energy-efficiency measures and indoor air quality.

GLOBAL CLIMATE CHANGE EFFORTS

Efforts in global climate change will focus on further development of projects under the California Climate Change Center, including efforts that will support the development of more accurate economic, ecological, and climate modeling for the state. Efforts will also develop research road maps on inventory methods for greenhouse gases, climate change, and public health.

THE ENVIRONMENTAL EXPLORATORY GRANT PROGRAM

This program will fund a new round of projects supporting a wide variety of energy-related environmental research. Awards are expected to be announced in October 2004.

ENERGY SYSTEMS INTEGRATION

Plans for 2004 in this program area will target three key areas: demand response, integrating distributed energy resources, and transmission.

DEMAND RESPONSE

The DR program will be quite active in 2004. Two projects that were begun in 2002 are expected to publish their final reports in 2004. In addition, a new control and communications integration (C2I) initiative and a DR research center are expected to be approved for funding.

CERTS, Oak Ridge National Laboratory, and CA ISO developed a research agenda to identify (1) how responsive loads could increase power system reliability and adequacy, (2) what behaviors are desirable, and (3) what reliability services (ancillary services) responsive loads could provide. The final report will be published in 2004 and used to prioritize a research agenda, using DR as a reliability tool.

LBNL was funded to study dynamic pricing and DR programs in New York State to evaluate the New York experience with respect to how it might be used in California to create price-responsive load. The final report will be published in 2004.

A DR research center at LBNL has been proposed and is awaiting final approval in 2004. The main objective of the center is to develop, prioritize, conduct, and disseminate research that develops broad knowledge with the aim of facilitating the near-term adoption of DR technologies, policies, programs, strategies, and practices, while ensuring that the research continues to be connected with the DR market and policy makers through substantial stakeholder input.

INTEGRATING DISTRIBUTED ENERGY RESOURCES

A project to provide a methodology to analyze whether DER additions can reduce losses and improve voltage profile in an integrated distribution and transmission power delivery network will be completed in 2004.

To improve the reliability of the California interconnected power system, PIER will initiate a \$3 million project with CERTS on "micro-grids." This project will create the technologies and control strategies needed to capture the full potential of distributed energy resources. The tasks that will be initiated in 2004 include demonstration of control systems and instrumentation for real-time power management and dispatch among DG resources.

TRANSMISSION

Work has begun on implementing the recently finalized five-year transmission research plan. A policy advisory committee will meet to provide strategic program guidance; the committee includes representatives from the California IOUs, the CA ISO, the DOE, a western regional representative, and representatives from the environmental community and the CPUC. Work has already begun on two "first priority" research initiatives that have specific near-term application and high potential benefits, and that directly address California's critical transmission issues:

(1) use actual system conditions in place of worst-case conditions to increase thermal and stability limits, and (2) develop and refine transmission expansion planning tools and approaches.

PIER will complete the Electric System Seismic Safety and Reliability project with Pacific Gas and Electric. This project has been successful in developing technologies and protocols to mitigate damage caused by earthquakes through fragility testing of substations' 500 and 230 kilovolt (kV) disconnect switches, transformer bushings, and connectors. The development of new building structural performance simulation tools for use by utilities located in earthquake zones will be completed.

With PIER support, CA ISO will pioneer the first-ever, *real-time* application of an advanced grid monitoring technology called phasors. The objective of the new workstations is to provide grid operators with phasor data in real time so that they can obtain a more accurate picture of the actual health of the grid. Ultimately, real-time data provided by phasor and other advanced real-time monitoring technologies will support a future automatic, switchable grid that can identify and respond automatically to warning signs of grid emergencies.

ENERGY INNOVATIONS SMALL GRANT

In 2004, the EISG program will continue to provide funds, through competitive solicitations, to determine the concept feasibility of a variety of research proposals. In addition, the 2004 program will incorporate the capability to assist EISG projects that produce results of special applicability to California's energy issues with business planning, securing intellectual property rights, conducting market analyses, and providing links to sources of follow-on funding.

Technology transfer activities will also be strengthened in 2004, which will produce a long-term technology transfer plan. There will be improved communication between EISG and the other PIER program areas to increase the overall coordination of the PIER program. Independent analysis reports, prepared by EISG at the conclusion of each project, will be restructured to be more effective in attracting follow-on funding for completed grant projects.



ACKNOWLEDGMENTS

The Energy Commission wishes to acknowledge the invaluable contributions made by staff, the members of the PIER Independent Review Panel, and the many concerned citizens who have actively participated in PIER-related advisory groups, planning focus groups, and other program forums to date. This participation has provided essential input throughout the program's development, and the Energy Commission will continue to seek such input and assistance in the future as it strives to further develop and improve the PIER program. Finally, the Energy Commission wishes to acknowledge the many highly talented and creative researchers and research organizations participating in the PIER program. Without the team effort of these various dedicated participants, the important public benefits of the PIER program could not be achieved.

PIER Oversight

Research, Development, and Demonstration Committee
Arthur H. Rosenfeld, Commissioner and Presiding Member
John L. Geesman, Commissioner and Second Member

PIER Program Management

Terry Surles, Program Director Ron Kukulka, Deputy Division Chief

PIER Program Area Team Leads

Mike Batham, Environmentally-Preferred Advanced Generation Kelly Birkinshaw, Energy-Related Environmental Research Nancy Jenkins, Residential and Commercial Buildings End-Use Energy Efficiency Pramod Kulkarni, Industrial/Agriculture/Water End-Use Energy Efficiency George Simons, Renewable Energy Technologies Laurie ten Hope, Energy Systems Integration

PIER Energy Innovations Small Grant Program

Alec Jenkins

PIER Annual Report

Gary Klein, Project Manager and Contributing Author
Rita Champlion, PIER Information Management System (PIMS) Project Manager
Lawrence Kinser, PIMS Database Consultant
Elizabeth Parkhurst, Editor, Media and Public Communications Office

Contributing Staff

Donald Aumann Gina Barkalow Sandra Barnett John Beyer Avtar Bining Stan Blois Martha Brook John Butler Sunni Chacon **David Chambers** Kathy Chan Diana Chen Judi Efhan Arthur Firebaugh Elizabeth Flores Guido Franco Mike Gravely Pablo Gutierrez Sherri Guzman Sandy Harris

Michael Heintz Brian Helmowski Darcie Houck Jack Janes Lisa Johnson MyoungAe Jones Jagmeet Kahlon Harriet Kallemeyn Michael Kane Rajesh Kapoor Linda Kelly Nancy Libonati Gina Lopez Mike Magaletti Susan Mattox Joseph McCabe David Michel Philip Misemer Hassan Mohammed David Navarro

Tuong Van Nguyen Joe O'Hagan Reta Ortiz Joan Parks Jamie Patterson Roger Peake Peg Pigeon-Bergmann Cheryl Raedel **Heather Raitt** Mark Rawson Paul Roggensack Jesselyn Rosales Jeffrey Rowe Rachel Salazar **Roy Sanders** Chris Scruton Prab Sethi Kristine Silva

Elaine Sison-Lebrilla

Art Soinski

Philip Spartz Linda Spiegel Elizabeth Stone Eric Stubee Julie Talbert Frank Taniguchi Valentino Tiangco Jing Tong Chrissie Vath Allan Ward Shelly Wallace Webteam Gail Wiggett Steve Williams Dora Yen Andrea Ygnacio Zhiqin Zhang

SAIC and ICF Staff

Gail Fink Hang Hennessey Karen Knee David Matson Rob Taylor



INDEPENDENT REVIEW PANEL

Public Resources Code (PRC Section 25620.9) requires that an independent panel of experts be assembled to review the public value of the PIER program. The original panel submitted their written evaluations to the Governor and Legislature in March 2000 and March 2001.

SB 1038, enacted in September 2002, mandated that a new panel of experts be designated to provide a follow-on review of the PIER program. The Energy Commission RD&D Committee designated a panel composed of independent experts in energy technology RD&D, economics and markets, energy policy, environmental impacts, public health, and government systems. The current panel members include the following:

Robert P. Caren

Board of Director of Litex Inc., Chairman of Hawkeye Enterprises

Linda R. Cohen

Professor of Economics, University of California, Irvine

T. Kenneth Fowler

Professor Emeritus, Nuclear Engineering, University of California, Berkeley

Harold M. (Hub) Hubbard

Energy Consultant, Energy and Environmental Issues

Alan C. Lloyd

California Air Resources Board Chairman

Johnetta A. MacCalla

Chief Executive Officer, Automated Switching and Controls, Inc.

William J. McLean

Director, Combustion Research Facility, Sandia National Laboratories, Livermore, California

Peter M. Miller

Natural Resources Defense Council

Maxine L. Savitz

General Manager (Ret.), Technology Partnerships, Honeywell, Inc.

Jan Sharpless,

Consultant

Esteban Soriano

Vice Chancellor, University Advancement, University of California, Merced

Arnold Sowell

Under Secretary, State and Consumer Services Agency

James L. Sweeney

Professor of Management Science and Engineering, Stanford University

Carl J. Weinberg

Weinberg Associates

Irvin L. (Jack) White

The Winslow Group

The panel met bimonthly, beginning in June 2003, to conduct a comprehensive evaluation of the PIER program. Their evaluation includes a review of the public value, including but not limited to the monetary and nonmonetary benefits of public health and the environment and the benefit of providing funds for technology development that would otherwise not be funded. Specifically, the panel reviewed the status of the PIER program's response to previous IRP recommendations. The panel plans to submit a preliminary report containing written findings and recommendations to the Governor and Legislature in March 2004 and a final report in January 2005.

2003 PIER ANNUAL REPORT 45

ENDNOTES

- 1. Public Resources Code Chapter 7.1, Section 25620 et seq. Funding for this program is provided by the electric ratepayers of Pacific Gas and Electric, San Diego Gas and Electric, and Southern California Edison.
- 2. Evaluation of the Public Benefits to California Electric Ratepayers from the Public Interest Energy Research (PIER) Program 1998–2002, California Energy Commission, Sacramento, CA, May 2003, publication number P500-03-024F, http://www.energy.ca.gov/pier/reports/500-03-024f.html.
- 3. *Integrated Energy Policy Report*, California Energy Commission, Sacramento, CA, December 2003, publication number P100-03-019F, pages 5 and vii, respectively, http://www.energy.ca.gov/reports/100-03-019F.PDF.
- 4. Graph prepared by Pat McAuliffe from information contained in the *Database of Proposed Generation within the Western Electricity Coordinating Council*, California Energy Commission, Sacramento, CA, updated February 5, 2004, http://www.energy.ca.gov/electricity/wscc_proposed_generation.html.
- 5. The Energy Commission develops and maintains appliance energy-efficiency standards and building efficiency standards pursuant to Public Resources Code 25402 et seq. California Code of Regulations, Title 20, Division 2, Chapter 4, Article 4, Sections 1601–1618 codifies the appliance standards,

http://www.energy.ca.gov/reports/2003-09-10_400-03-016PDF.
California Code of Regulations, Title 24, Part 6, codifies the buildings energy-efficiency regulations,

http://www.energy.ca.gov/title24.

- 6. 2003 Energy Action Plan, Consumer Power and Conservation Financing Authority, the Energy Resources Conservation and Development Commission, and the Public Utilities Commission, April and May 2003, page 5,
 - http://www.energy.ca.gov/2003_energy_action_plan/index.html.
- 7. See endnote 3, IEPR, page 13. Partly in response to concerns about growing natural gas dependence, the Legislature passed Senate Bill 1078 [Chapters 516, Statutes of 2002, Sher] establishing the RPS. The RPS requires that all retail suppliers of electricity in the state develop an RPS program and that IOUs supply at least 20 percent of their sales from renewable energy resources by 2017.

- 8. Senate Bill 1478 (Sher). As introduced in February 2004, Section 25740 was been amended to read: It is the intent of the Legislature in establishing this program, to increase the amount of renewable electricity generated per year, so that it equals at least 20 percent of the total electricity generated for consumption in California per year by the year 2010 and at least 33 percent by the year 2020.
- 9. Senate Bill 1078 [Chapters 516, Statutes of 2002, Sher], Section 399.14(a) (2)(B).
- 10. California Renewables Portfolio Standard Renewable Generation Integration Cost Analysis, *Phase 1*, California Energy Commission, December 2003, publication number P500-03-108C, http://www.energy.ca.gov/reports/2004-02-05_500-03-108C.PDF.
- 11. Based on data used to develop IOU Rule 21. For a discussion of Rule 21, refer to http://www.energy.ca.gov/distgen/interconnection/california_requirements.html.
- 12. Nicholas Lenssen, Converting Prospects to Customers: What Users Say About DE, CADER's Distributed Energy Resources Conference, Sustaining the Momentum: Delivering the Benefits, January 27, 2004.
- 13. California Interconnection Guidebook: A Guide to Interconnecting Customer-owned Electric Generation Equipment to the Electric Utility Distribution System Using California's Electric Rule 21, California Energy Commission, September 2003, publication number P500-03-083, http://www.energy.ca.gov/reports/2003-11-13_500-03-083F.PDF.
- 14. See endnote 11.
- 15. See endnote 2.
- 16. One product, Poultry Rinse Recycling, was presented as a success in 2002 but is no longer offered commercially; it has been removed from the table.

